a substrate having a first surface and electrodes;

a resin film formed on the substrate, formed from a material having an energy beam sensitive group and a thermoreactive group, wherein the energy beam sensitive groups are reacted and crosslinked.

72. (New) A liquid crystal alignment member according to claim 71, wherein the resin film is formed directly on the electrodes.

73. (New) A liquid crystal alignment member according to claim 71, wherein the substrate comprises a film between the resin film and the electrodes.

REMARKS

The above amendments make editorial revisions in the specification. The nature of the revision to page 9, line 20 is clear from page 9, line 17. The correction of the Examples on page 16 is clear from pages 30 and 32. The revision to page 34 is supported by Fig. 11. The correction of the figures at pages 39 and 49 is clear from the context and the figures in question. The revision to page 54 is an apparent clarification. The claims have been revised in accordance with the formalities of U.S. practice and to eliminate multiple dependencies.

A courtesy copy of the present specification is enclosed herewith, but the World Intellectual Property Office (WIPO) copy should be relied upon if it is already in the U.S. Patent Office.

Applicant respectfully requests that the preliminary amendment described herein be entered into the record prior to examination and consideration of the above-identified application.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicant's primary attorney-of record, Douglas P. Mueller (Reg. No. 30,300), at (612) 371-5237.

Respectfully submitted,

MERCHANT & GOULD P.C.
P.O. Box 2903
Minneapolis, MN 55402-0903
(612) 332-5300

Dated: December 5, 2001

By: Curtis B. Hamre
Curtis B. Hamre
Reg. No. 29,165
DPM/tvm

MARKED-UP COPY

IN THE SPECIFICATION

Please amend the following paragraph beginning on page 9, line 20:

In the above-mentioned method, a plurality of types of [silicon-based] silane-based surfactants each having a different critical surface energy are preferably mixed and used as the surfactant. This makes it possible to control the critical surface energy of the film more precisely.

Please delete the following paragraph beginning on page 10, line 31, and ending on page 11:

The above-mentioned method preferably includes the steps of applying and forming a resin film transparent in a visible light range and having energy beam sensitive groups and thermoreactive groups on a predetermined surface of a substrate provided with electrodes directly or indirectly via an arbitrary thin film, and at least irradiating the resin film with energy beams through an arbitrary mask so as to react and crosslink the energy beam sensitive groups.

Please amend the following paragraph beginning on page 16, line 12:

Figure 8 is a view for illustrating a process for generating carboxyl groups newly by a second exposure in Example [3] 2 of the present invention.

Please amend the following paragraph beginning on page 16, line 15:

Figure 9 is a schematic cross-sectional view of a liquid crystal alignment film for illustrating a state where two types of chemisorption films each having a different alignment direction are formed in Example [3] 2.

Please amend the following paragraph beginning on page 16, line 17:

Figure 10 is a schematic cross-sectional view enlarged to a molecular level for illustrating a state where a siloxane monomolecular film is formed in Example [4] 3 of the present invention.

Please amend the following paragraph beginning on page 34, line 11:

Such a device was able to display images in the direction shown by arrow [A] C by being entirely irradiated with blacklight 53 and by driving each transistor with video signals.

Please amend the following paragraph beginning on page 39, line 3:

Furthermore, since the thus obtained siloxane monomolecular film 72 was firmly bonded to the substrate via the chemical bonds of -SiO-, it was not peeled off. Furthermore, the obtained monomolecular film has a large number of SiOH bonds on its surface. The SiOH bonds were generated in a number about twice or three times the original number of -OH groups. The treated portion in this state was highly hydrophilic. Then, in this state, when the chemisorption process was performed by using the same surfactant as in Example 5, the same monomolecular chemisorption film comprising carbon chains obtained as a result of the reaction of the surfactant as in Figure [12] 14 was formed in a thickness of about 1 nm by being chemically bonded through covalent bonds of siloxane via the siloxane monomolecular film. At this time, since the adsorption sites (OH groups in this case) on the surface of the substrate before the adsorption of the surfactant were about twice or three times as many as that in Example 5, the density of the adsorbed molecules was larger than that of Example 5. Furthermore, the treated portion became lipophilic. The molecules of the chemisorption film in this case, although having a different

molecular density, were aligned in the direction opposite to the lifting direction, namely the direction in which the solution had been drained off.

Please amend the following paragraph beginning on page 48, line 30:

Furthermore, since the thus obtained siloxane monomolecular film 112 was firmly bonded to the substrate via chemical bonds of -SiO-, it was not peeled off. Furthermore, the obtained monomolecular film has a large number of SiOH bonds on its surface. The SiOH bonds were generated in a number about twice or three times the original number of -OH groups. The treated portion in this state was highly hydrophilic. Then, in this state, when the chemisorption process was performed by using the same surfactant as in Example 12, the same monomolecular chemisorption film comprising carbon chains obtained as a result of the reaction of the surfactant as in figure [23] 25 was formed in a thickness of about 1.5 nm by being chemically bonded through covalent bonds of siloxane via the siloxane monomolecular film 112. At this time, since the adsorption sites (OH groups in this case) on the surface of the substrate before adsorption were about twice or three times as many as that in Example 12, the density of the adsorbed molecules was higher than that of Example 12. The treated portion became lipophilic. The molecules of the chemisorption film in this case, although having a different molecular density were aligned in the direction opposite to the lifting direction, namely the direction in which the solution had been drained off.

Please amend the following paragraph beginning on page 54, line 22:

Furthermore, the following compounds comprising a siloxane bond chain and a chlorosilyl group, or an alkoxysilane group or an isocyanate [silane] <u>silyl</u> group were usable. In this case as well, a film having a high alignment was obtained.

<u>IN THE CLAIMS</u>

8. (Amended) The liquid crystal alignment film according to claim [7] <u>69</u>, wherein the molecules constituting the film contain carbon chains or siloxane bond chains.

10. (Amended) The liquid crystal alignment film according to [any one of claims 7 to 9] <u>claim 69</u>, wherein the molecules constituting the film have Si at both ends.

11. (Amended) The liquid crystal alignment film according to [any one of claims 7 to 9] <u>claim 69</u>, wherein the molecules constituting the film are formed by mixing a plurality of types of chemisorption molecules having different molecular lengths, and the fixed film has concavities and convexities at a molecular length level.

13. (Amended) The liquid crystal alignment film according to claim [12] <u>70</u>, wherein a plurality of types of silane-based surfactants, each having a different critical surface energy, are mixed and used as the molecules constituting the film, and the fixed film is controlled so as to have a desired critical surface energy.

14. (Amended) The liquid crystal alignment film according to claim [12 or 13] 70, wherein the functional group for controlling the surface energy is at least one organic group selected from the group consisting of a carbon trifluoride group (-CF_3), a methyl group (-CH_3), a vinyl group (-CH = CH_2), an allyl group (-CH = CH-), an acetylene group (triple bonds of carbon - carbon), a phenyl goup (-C_6H_5), an aryl group (-CH_6H_4 -), a halogen atom, an alkoxy goup (-OR; R represents an alkyl group), a cyano group (-CN), an amino group (-NH_2), a hydroxyl group (-OH), a carbonyl group (=CO), an ester group (-COO -) and a carboxyl group (-COOH).

15. (Amended) The liquid crystal alignment film according to [any one of claims 12 to 14] claim 70, wherein the molecules constituting the film contain Si at the terminals.

17. (Amended) The liquid crystal alignment film according to claim [16] 71, wherein the energy beam sensitive groups and the thermoreactive groups are introduced as side chain groups in the resin film.

18. (Amended) The liquid crystal alignment film according to claim [16] 71, wherein the energy beam sensitive groups, the thermoreactive groups and hydrocarbon groups are introduced as side chain groups in the resin film.

19. (Amended) The liquid crystal alignment film according to claim [16] 71, wherein the surface of the resin film has striped concavities and convexities.

20. (Amended) The liquid crystal alignment film according to [any one of claims 16 to 19] claim 71, wherein the thermoreactive groups are reacted and crosslinked.

25. (Amended) The method for producing a liquid crystal alignment film according to claim 23 [or 24], wherein the energy beams are at least one light selected from the group consisting of ultraviolet rays, visible rays and infrared rays, and the energy beam sensitive resin film is a photosensitive resin film.

27. (Amended) The method for producing a liquid crystal alignment film according to [any one of claims 22 to 26] claim 22, wherein a solvent including a carbon fluoride group is used as a nonaqueous solvent.

30. (Amended) The method for producing a monomolecular liquid crystal alignment film according to claim 28 [or 29], wherein a silane-based surfactant containing linear hydrocarbon groups or siloxane bond chains and chlorosilyl groups, alkoxysilyl groups or isocyanate silyl groups is used as the surfactant.

32. (Amended) The method for producing a monomolecular liquid crystal alignment film according to claim 30 [or 31], wherein a carbon of a part of the hydrocarbon group has an optical activity.

33. (Amended) The method for producing a monomolecular liquid crystal alignment film according to [any one of claims 30 to 32] claim 30, wherein the hydrocarbon group or the

siloxane bond chain contains a halogen atom or a methyl group (-CH_3, a phenyl group (-C_6H_5), a cyano group (-CN), a hydroxyl group (-OH), a carboxyl group (-COOH), an amino group (-NH_2), or a carbon trifluoride group (-CF_3) at the terminal.

35. (Amended) The method for producing a monomolecular liquid crystal alignment film according to [any one of claims 30 to 34] claim 30, wherein a silane-based surfactant containing linear hydrocarbon groups or siloxane bond chains and chlorosilyl groups or isocyanate silyl groups is used as the surfactant, and a nonaqueous organic solvent containing no water is used as the washing organic solvent.

37. (Amended) The method for producing a monomolecular liquid crystal alignment film according to [any one of claims 28 to 36] claim 28, wherein a film containing a large number of SiO groups is formed before the step of fixing the surfactant molecules, and then a monomolecular film is formed via this film.

40. (Amended) The method for producing a monomolecular liquid crystal alignment film according to claim 38 [or 39], wherein a plurality of types of [silicon-based] silane-based surfactants having different critical surface energies are mixed and used as the surfactant.

41. (Amended) The method for producing a monomolecular liquid crystal alignment film according to [any one of claim 38 or 40] claim 38, wherein a terminal or a part of the carbon chain or the siloxane bond chain comprises at least one organic group selected from the group consisting of a carbon trifluoride group (- CF_3), a methyl group (- CH_3), a vinyl group (- CH =

CH_2), an allyl group (- CH = CH-), an acetylene group (triple bonds of carbon - carbon), a phenyl group (- C_6H_5), an aryl group (- C_6H_4 -), a halogen atom, an alkoxy group (-OR; R represents an alkyl group), a cyano group (- CN), an amino group (- NH_2), a hydroxyl group (- OH), a carbonyl group (= CO), an ester group (- COO -) and a carboxyl group (- COOH).

42. (Amended) The method for producing a monomolecular liquid crystal alignment film according to [any one of claim 38 or 41] claim 38, further comprising the steps of washing the substrate with an organic solvent after the step of bonding and fixing the surfactant molecules to the surface of the substrate at one end, and tilting the substrate in a desired direction so as to drain off the solvent, thereby aligning the fixed molecules in the direction in which the solvent was drained off.

44. (Amended) The method for producing a monomolecular liquid crystal alignment film according to claim 42 [to 43], wherein a silane-based surfactant containing linear carbon chains or siloxane bond chains and chlorosilyl groups or isocyanate [silane] silyl groups is used as the surfactant, and a nonaqueous organic solvent containing no water is used as the washing organic solvent.

46. (Amended) The method for producing a monomolecular liquid crystal alignment film according to [any one of claims 38 to 45] claim 38, further comprising the step of forming a film containing a large number of SiO groups before the step of fixing the surfactant molecules, and then forming a monomolecular film via this film.

49. (Amended) The method for producing a liquid crystal alignment film according to claim 47 [or 48], wherein the energy beam sensitive groups are photosensitive groups, and the resin film is irradiated with ultraviolet rays through a mask so that the photosensitive groups in the resin film react not only to crosslink between principal chains but also to align and fix side chain groups.

50. (Amended) The method for producing a liquid crystal alignment film according to [any one of claims 47 to 49] claim 47, wherein a polarizing film or a diffraction grating is used as the mask for exposure.

51. (Amended) The method for producing a liquid crystal alignment film according to [any one of claims 47 to 50] claim 47, wherein in the step of exposure, the resin film is exposed to light to an extent that concavities and convexities are generated on the surface thereof.

55. (Amended) The liquid crystal display apparatus according to claim 53 [or 54], wherein the film on the surface of the substrate comprises a plurality of patterned sections each having a different alignment direction.

59. (Amended) The liquid crystal display apparatus according to claim 57 [or 58], wherein the film on the surface of the substrate comprises a plurality of patterned sections, each having a different alignment direction.

AMENDED CLAIMS UNDER ARTICLE 19

1. A liquid crystal alignment film, which is a film wherein a silane-based surfactant having a linear carbon chain and Si is chemically adsorbed via an energy beam sensitive resin film for generating functional groups containing active hydrogen by energy beam irradiation formed on a predetermined surface of a substrate, where the linear carbon chains are aligned in a specific direction.

2. The liquid crystal alignment film according to claim 1, wherein the film formed of the surfactant is fixed to the energy beam sensitive resin film via covalent bonds on the surface of the substrate in a striped pattern.

3. The liquid crystal alignment film according to claim 2, wherein the fixed film formed of the surfactant is fixed to the energy beam sensitive resin film via a film having siloxane bonds.

4. The liquid crystal alignment film according to any one of claims 1 to 3, wherein the silane-based surfactant is a chlorosilane-based surfactant containing a linear hydrocarbon group and a chlorosilyl group.

5. The liquid crystal alignment film according to claim 4, wherein a part of hydrogen of the linear hydrocarbon group of the chlorosilane-based surfactant is substituted with at least a fluorine atom.

6. The liquid crystal alignment film according to claim 4 or 5, wherein a plurality of types of chlorosilane-based surfactants, each having a different molecular length, are mixed and used as the chlorosilane-based surfactant containing a linear hydrocarbon group and a chlorosilyl group.

7. A liquid crystal alignment film, which is a monomolecular film formed on a surface of a substrate provided with desired electrodes, wherein the molecules constituting the film have a desired tilt defined by fixing the molecules constituting the film to the substrate by covalent bonds, washing

the molecules with an organic solvent, and tilting the substrate in a desired direction so as to drain off the solvent, and are bonded and fixed to the surface of the substrate at one end while being aligned uniformly in a specific direction.

8. The liquid crystal alignment film according to claim 7, wherein the molecules constituting the film contain carbon chains or siloxane bond chains.

9. The liquid crystal alignment film according to claim 8, wherein a carbon of a part of the carbon chain has an optical activity.

10. The liquid crystal alignment film according to any one of claims 7 to 9, wherein the molecules constituting the film have Si at both ends.

11. The liquid crystal alignment film according to any one of claims 7 to 10, wherein the molecules constituting the film are formed by mixing a plurality of types of chemisorption molecules having different molecular lengths, and the fixed film has concavities and convexities at a molecular length level.

12. A liquid crystal alignment film, which is a monomolecular film formed on a surface of a substrate provided with desired electrodes, wherein the molecules constituting the film have carbon chains or siloxane bond chains, and at least a part of the carbon chain or the siloxane bond chain contains at least a functional group for controlling a surface energy of the film, and the critical surface energy of the film is controlled to be a desired value between 15 mN/m to 56 mN/m.

13. The liquid crystal alignment film according to claim 12, wherein a plurality of types of silane-based surfactants, each having a different critical surface energy, are mixed and used as the molecules constituting the film, and the fixed film is controlled so as to have a desired critical surface energy.

14. The liquid crystal alignment film according to claim 12 or 13, wherein the functional group for controlling the surface energy is at least one organic

Sub Cont B11

group selected from the group consisting of a carbon trifluoride group ($-CF_3$), a methyl group ($-CH_3$), a vinyl group ($-CH=CH_2$), an allyl group ($-CH=CH-$), an acetylene group (triple bonds of carbon – carbon), a phenyl group ($-C_6H_5$), an aryl group ($-C_6H_4-$), a halogen atom, an alkoxy group ($-OR$; R represents an alkyl group), a cyano group ($-CN$), an amino group ($-NH_2$), a hydroxyl group ($-OH$), a carbonyl group ($=CO$), an ester group ($-COO-$) and a carboxyl group ($-COOH$).

15. The liquid crystal alignment film according to any one of claims 12 to 14, wherein the molecules constituting the film contain Si at the terminals.

16. A liquid crystal alignment film, wherein a resin film transparent in visible light range and having energy beam sensitive groups and thermoreactive groups is formed directly on electrodes or indirectly via an arbitrary thin film, and at least the energy beam sensitive groups are reacted and crosslinked.

B12

17. The liquid crystal alignment film according to claim 16, wherein the energy beam sensitive groups and the thermoreactive groups are introduced as side chain groups in the resin film.

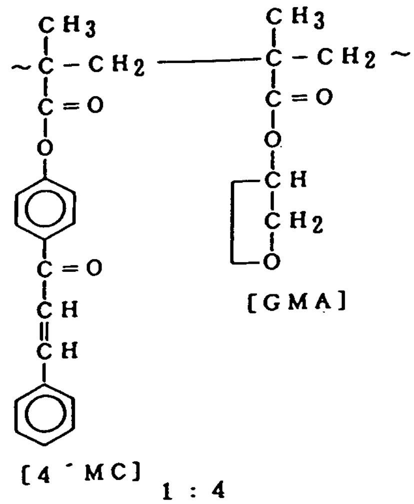
18 The liquid crystal alignment film according to claim 16, wherein the energy beam sensitive groups, the thermoreactive groups and hydrocarbon groups are introduced as side chain groups in the resin film.

19. The liquid crystal alignment film according to claim 16, wherein the surface of the resin film has striped concavities and convexities.

20. The liquid crystal alignment film according to any one of claim 16 to 19, wherein the thermoreactive groups are reacted and crosslinked.

21. The liquid crystal alignment film according to claim 16, wherein a substance represented by (formula 1) is used as the resin film.

(formula 1)



22. A method for producing a liquid crystal alignment film comprising the steps of applying and forming an energy beam sensitive resin film for generating functional groups containing active hydrogen by energy beams directly or indirectly via an arbitrary thin film on a predetermined surface of a substrate provided with electrodes, irradiating the surface of the resin film with energy beams in an arbitrary pattern, contacting the irradiated resin film with a chemisorption solution containing a silane-based surfactant having linear carbon chains and Si groups, washing the substrate with a solvent incapable of dissolving the resin film, thereby forming one layer of a monomolecular film formed of the surfactant selectively in the irradiated portion, and aligning and fixing the linear carbon chains in the surfactant molecules.

23. The method for producing a liquid crystal alignment film according to claim 22, wherein the energy beams are at least one selected from the group consisting of electron beams, X rays or light with a wavelength of 100 nm to 1 μm.

24. The method for producing a liquid crystal alignment film according to claim 23, wherein the chemisorption solution contains at least a chlorosilane-based surfactant comprising a linear carbon chain and a chlorosilyl group and

a solvent that causes no damage to the energy beam sensitive resin film.

25. The method for producing a liquid crystal alignment film according to claim 23 or 24, wherein the energy beams are at least one light selected from the group consisting of ultraviolet rays, visible rays and infrared rays, and the energy beam sensitive resin film is a photosensitive resin film.

26. The method for producing a liquid crystal alignment film according to claim 25, wherein the photosensitive resin film is a polymer film or a monomer film containing at least one organic group selected from the group consisting of a group represented by (formula 2), a group represented by (formula 3) and a group represented by (formula 4).

(formula 2)

$$-\overset{\overset{\displaystyle N_2}{\|}}{C}-\overset{\overset{\displaystyle O}{\|}}{C}-$$

(formula 3)

$$-\overset{\overset{\displaystyle O}{\|}}{C}-O-N=\underset{|}{\overset{|}{C}}$$

(formula 4)

$$-SO_2-O-\underset{\underset{\displaystyle CH_3}{|}}{\overset{\overset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle O}{\|}}{C}-CH_3$$

27. The method for producing a liquid crystal alignment film according to any one of claims 22 to 26, wherein a solvent including a carbon fluoride group is used as a nonaqueous solvent.

28. A method for producing a monomolecular liquid crystal alignment film comprising the steps of contacting a substrate provided with electrodes with a chemisorption solution so as to cause a chemical reaction between molecules of a surfactant in the adsorption solution and a surface of the substrate, thereby bonding and fixing the surfactant molecules to the surface of the substrate at one end, washing the substrate with an organic solvent, and tilting the substrate in a desired direction so as to drain off the solvent, thereby aligning the fixed molecules in the direction in which the solvent was drained off.

29. The method for producing a monomolecular liquid crystal alignment film according to claim 28 further comprising the step of exposing the substrate to light polarized in a desired direction via a polarizing plate after the step of aligning the molecules, so as to align the orientations of the surfactant molecules uniformly in a specific direction at a desired tilt.

B15

30. The method for producing a monomolecular liquid crystal alignment film according to claim 28 or 29, wherein a silane-based surfactant containing linear hydrocarbon groups or siloxane bond chains and chlorosilyl groups, alkoxysilyl groups or isocyanate silyl groups is used as the surfactant.

31. The method for producing a monomolecular liquid crystal alignment film according to claim 30, wherein a plurality of types of silane-based surfactants, each having a different molecular length, are mixed and used as the silane-based surfactant containing linear hydrocarbon groups or siloxane bond chains and chlorosilyl groups, alkoxysilyl groups or isocyanate silyl groups.

B16

32. The method for producing a monomolecular liquid crystal alignment film according to claim 30 or 31, wherein a carbon of a part of the hydrocarbon group has an optical activity.

33. The method for producing a monomolecular liquid crystal alignment film according to any one of claims 30 to 32, wherein the hydrocarbon group or the siloxane bond chain contains a halogen atom or a methyl group ($-CH_3$), a

phenyl group ($-C_6H_5$), a cyano group ($-CN$), a hydroxyl group ($-OH$), a carboxyl group ($-COOH$), an amino group ($-NH_2$), or a carbon trifluoride group ($-CF_3$) at the terminal.

34. The method for producing a monomolecular liquid crystal alignment film according to claim 29, wherein light that is used for exposure is light having at least one wavelength selected from the group consisting of 436 nm, 405 nm, 365 nm, 254 nm and 248 nm.

35. The method for producing a monomolecular liquid crystal alignment film according to any one of claims 30 to 34, wherein a silane-based surfactant containing linear hydrocarbon groups or siloxane bond chains and chlorosilyl groups or isocyanate silyl groups is used as the surfactant, and a nonaqueous organic solvent containing no water is used as the washing organic solvent.

36. The method for producing a monomolecular liquid crystal alignment film according to claim 35, wherein a solvent containing an alkyl group, a carbon fluoride group or a carbon chloride group or a siloxane group is used as the nonaqueous organic solvent.

37. The method for producing a monomolecular liquid crystal alignment film according to any one of claims 28 to 36, wherein a film containing a large number of SiO groups is formed before the step of fixing the surfactant molecules, and then a monomolecular film is formed via this film.

38. A method for producing a monomolecular liquid crystal alignment film comprising the steps of contacting a substrate provided with electrodes with a chemisorption solution produced by using a silane-based surfactant containing carbon chains or siloxane bond chains, at least a part of the carbon chain or the siloxane bond chain containing at least one functional group for controlling a surface energy of a formed film, thereby causing a chemical reaction between the surfactant molecules in the adsorption solution and the surface of the substrate so as to bond and fix the surfactant molecules to the surface of the substrate at one end.

39. The method for producing a monomolecular liquid crystal alignment film according to claim 38, wherein a silane-based surfactant containing linear carbon chains or siloxane bond chains and chlorosilyl groups, alkoxysilyl groups or isocyanate silyl groups is used as the surfactant.

40. The method for producing a monomolecular liquid crystal alignment film according to claim 38 or 39, wherein a plurality of types of silicon-based surfactants having different critical surface energies are mixed and used as the surfactant.

41. The method for producing a monomolecular liquid crystal alignment film according to any one of claim 38 or 40, wherein a terminal or a part of the carbon chain or the siloxane bond chain comprises at least one organic group selected from the group consisting of a carbon trifluoride group ($-CF_3$), a methyl group ($-CH_3$), a vinyl group ($-CH=CH_2$), an allyl group ($-CH=CH-$), an acetylene group (triple bonds of carbon - carbon), a phenyl group ($-C_6H_5$), an aryl group ($-C_6H_4-$), a halogen atom, an alkoxy group ($-OR$; R represents an alkyl group), a cyano group ($-CN$), an amino group ($-NH_2$), a hydroxyl group ($-OH$), a carbonyl group ($=CO$), an ester group ($-COO-$) and a carboxyl group ($-COOH$).

42. The method for producing a monomolecular liquid crystal alignment film according to any one of claim 38 or 41, further comprising the steps of washing the substrate with an organic solvent after the step of bonding and fixing the surfactant molecules to the surface of the substrate at one end, and tilting the substrate in a desired direction so as to drain off the solvent, thereby aligning the fixed molecules in the direction in which the solvent was drained off.

43. The method for producing a monomolecular liquid crystal alignment film according to claim 42 further comprising the step of exposing the substrate to light via a polarizing film after the step of aligning the molecules, so as to realign the molecules in a desired direction.

44. The method for producing a monomolecular liquid crystal alignment film

Cont B19

according to claim 42 to 43, wherein a silane-based surfactant containing linear carbon chains or siloxane bond chains and chlorosilyl groups or isocyanate silane groups is used as the surfactant, and a nonaqueous organic solvent containing no water is used as the washing organic solvent.

45. The method for producing a monomolecular liquid crystal alignment film according to claim 44, wherein a solvent containing an alkyl group, a carbon fluoride group or a carbon chloride group or a siloxane group is used as the nonaqueous organic solvent.

B20

46. The method for producing a monomolecular liquid crystal alignment film according to any one of claims 38 to 45, further comprising the step of forming a film containing a large number of SiO groups before the step of fixing the surfactant molecules, and then forming a monomolecular film via this film.

47. A method for producing a liquid crystal alignment film comprising the steps of applying and forming a resin film transparent in a visible light range and having energy beam sensitive groups and thermoreactive groups on a predetermined surface of a substrate provided with electrodes directly or indirectly via an arbitrary thin film, and at least irradiating the resin film with energy beams through an arbitrary mask so as to react and crosslink the energy beam sensitive groups.

48. The method for producing a liquid crystal alignment film according to claim 47, wherein the step of reacting and crosslinking the thermoreactive groups by heating is added before or after the step of reacting and crosslinking the energy beam sensitive groups.

B21

49. The method for producing a liquid crystal alignment film according to claim 47 or 48, wherein the energy beam sensitive groups are photosensitive groups, and the resin film is irradiated with ultraviolet rays through a mask so that the photosensitive groups in the resin film react not only to crosslink between principal chains but also to align and fix side chain groups.

50. The method for producing a liquid crystal alignment film according to any one of claims 47 to 49, wherein a polarizing film or a diffraction grating is used as the mask for exposure.

51. The method for producing a liquid crystal alignment film according to any one of claims 47 to 50, wherein in the step of exposure, the resin film is exposed to light to an extent that concavities and convexities are generated on the surface thereof.

52. A liquid crystal display apparatus comprising a pair of substrates, electrodes and alignment films, the electrodes being formed on the surfaces of the substrates, the alignment films being formed thereon, liquid crystal being interposed between the counter electrodes on the two substrates via the alignment films,

wherein at least one alignment film is a film in which a silane-based surfactant having a linear carbon chain is chemically adsorbed via an energy beam sensitive film for generating a functional group containing active hydrogen by irradiation of energy beams, and the linear carbon chains are aligned in a specific direction.

53. A liquid crystal display apparatus, wherein a film is formed as an alignment film for liquid crystal directly on a surface provided with electrodes of at least one substrate of two substrates provided with counter electrodes or indirectly via another film, the film being a monomolecular film formed of a silane-based surfactant having linear carbon chains or siloxane bond chains, molecules constituting the film having a desired tilt and being bonded and fixed to the surface of the substrate at one end while being aligned uniformly in a specific direction, liquid crystal being interposed between the counter electrodes on the two substrates via the alignment film.

54. The liquid crystal display apparatus according to claim 53, wherein said film is formed on each of the surfaces of the two substrates provided with the counter electrodes as the alignment film.

Sub B23

55. The liquid crystal display apparatus according to claim 53 or 54, wherein the film on the surface of the substrate comprises a plurality of patterned sections each having a different alignment direction.

56. The liquid crystal display apparatus according to claim 53, wherein the counter electrodes are formed on a surface of one substrate.

57. A liquid crystal display apparatus, wherein a film is formed as an alignment film for liquid crystal directly on a surface provided with electrodes on at least one substrate of two substrates provided with counter electrodes or indirectly via another film, the film being constituted by molecules containing carbon chains or siloxane bond chains, a part of the carbon chain or the siloxane bond chain containing at least one functional group for controlling a surface energy of the film, liquid crystal being interposed between the counter electrodes on the two substrates via the alignment film.

58. The liquid crystal display apparatus according to claim 57, wherein said film is formed on each of the surfaces of the two substrates provided with the counter electrodes as the alignment film.

Sub B23

59. The liquid crystal display apparatus according to claim 57 or 58, wherein the film on the surface of the substrate comprises a plurality of patterned sections, each having a different alignment direction.

60. The liquid crystal display apparatus according to claim 57, wherein the counter electrodes are formed on a surface of one substrate.

61. A liquid crystal display apparatus, wherein a resin film transparent in a visible light range and having energy beam sensitive groups and thermoreactive groups is formed directly on electrodes or indirectly via an arbitrary thin film, and at least the energy beam sensitive groups are reacted and crosslinked, the thus obtained liquid crystal alignment film being formed on electrodes on at least one substrate of two substrates with counter electrodes, liquid crystal being interposed between the counter electrodes on

the two substrates via the resin film.

62. A method for producing a liquid crystal display apparatus comprising the steps of applying and forming an energy beam sensitive resin film for generating functional groups containing active hydrogen by energy beams directly or indirectly via an arbitrary thin film on a first substrate including first electrode arrays arranged in a matrix beforehand, irradiating the surface of the resin film with energy beams in an arbitrary pattern, contacting the substrate with the irradiated resin film with a chemisorption solution containing a silane-based surfactant having linear carbon chains and Si, washing the substrate with a solvent incapable of dissolving the resin film so as to form one layer of a monomolecular film formed of the surfactant selectively in the irradiated portion, and aligning and fixing the linear carbon chains, attaching the first substrate including the first electrode arrays to a second substrate including second electrodes or electrode arrays so that the respective electrodes are opposed with a predetermined gap, and injecting predetermined liquid crystal between the first substrate and the second substrate.

63. A method for producing a liquid crystal display apparatus comprising the steps of contacting a first substrate including first electrode arrays arranged in a matrix beforehand with a chemisorption solution directly or after forming an arbitrary thin film so as to cause a chemical reaction between the surfactant molecules in the adsorption solution and the surface of the substrate, thereby bonding and fixing the surfactant molecules to the surface of the substrate at one end, washing the substrate with an organic solvent, tilting the substrate in a desired direction so as to drain off the solvent, thereby aligning the fixed molecules in the direction in which the solvent is drained off, exposing the substrate to light polarized in a desired direction through a polarizing plate so as to align the orientations of the surfactant molecules uniformly in a specific direction at a desired tilt, attaching the first substrate including the first electrode arrays to a second substrate or a second substrate including second electrodes or electrode arrays so that the faces provided with the electrodes are facing inward with a predetermined gap, and

injecting predetermined liquid crystal between the first substrate and the second substrate.

64. The method for producing a liquid crystal display apparatus according to claim 63, wherein in the step of exposing the substrate to light polarized in a desired direction through a polarizing plate so as to align the orientations of the bonded surfactant molecules uniformly in a specific direction at a desired tilt, the step of exposure with a patterned mask disposed on the polarizing plate is performed several times so as to form a plurality of patterned sections each having a different orientation on one face of the alignment film.

65. A method for producing a liquid crystal display apparatus comprising the steps of contacting a first substrate including first electrode arrays arranged in a matrix beforehand with a chemisorption solution directly or after forming an arbitrary thin film, the chemisorption solution being produced by using a silane-based surfactant containing carbon chains or siloxane bond chains, at least a part of the carbon chain or the siloxane bond chain containing at least one functional group for controlling a surface energy of a formed film, so as to cause a chemical reaction between the surfactant molecules in the adsorption solution and the surface of the substrate, thereby bonding and fixing the surfactant molecules to the surface of the substrate at one end, washing the substrate with an organic solvent, tilting the substrate in a desired direction so as to drain off the solvent, thereby aligning the fixed molecules in the direction in which the solution is drained off, attaching the first substrate including the first electrode arrays to a second substrate or a second substrate including second electrodes or electrode arrays so that the faces provided with the electrodes are facing inward with a predetermined gap, and injecting predetermined liquid crystal between the first substrate and the second substrate.

66. The method for producing a liquid crystal display apparatus according to claim 65, further comprising the step of exposing the substrate to light polarized in a desired direction through a polarizing plate so as to align the orientations of the surfactant molecules uniformly in a specific direction at a

desired tilt after the step of aligning the fixed molecules.

67. The method for producing a liquid crystal display apparatus according to claim 66, wherein in the step of exposing the substrate to light polarized in a desired direction through a polarizing plate so as to align the orientations of the bonded surfactant molecules uniformly in a specific direction at a desired tilt, the step of exposure with a patterned mask disposed on the polarizing plate is performed several times, thereby forming a plurality of patterned sections, each having a different orientation on one face of the alignment film.

68. A method for producing a liquid crystal display apparatus comprising the steps of applying and forming a resin film transparent in a visible light range and having energy beam sensitive groups and thermoreactive groups directly or indirectly via an arbitrary thin film on a first substrate including first electrode arrays arranged in a matrix, at least irradiating the resin film with energy beams through an arbitrary mask so as to react and crosslink the energy beam sensitive groups, attaching the first substrate including the first electrode arrays to a second substrate including second electrodes or electrode arrays opposed to the first electrode arrays so that the respective faces provided with the electrodes are opposed to each other, and injecting predetermined liquid crystal between the first substrate and the second substrate.

Add B24